

# **Thermal performance of building products and components — Specific criteria for the assessment of laboratories measuring heat transfer properties —**

## **Part 5: Measurements by pipe test methods**

The European Standard EN 1946-5:2000 has the status of a  
British Standard

ICS 91.100.01; 91.120.10

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# National foreword

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## Summary of pages

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Thermal performance of building products and components -  
Specific criteria for the assessment of laboratories measuring  
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des conduites

Wärmetechnisches Verhalten von Bauprodukten und  
Bauteilen - Technische Kriterien von Begutachtung von  
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Wärmeübertragungseigenschaften - Teil 5: Messungen  
nach dem Rohrprüfgerät- Verfahren

This European Standard was approved by CEN on 10 April 2000.

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## Foreword

This European Standard has been prepared by Technical Committee CEN/TC 89, Thermal performance of buildings and building components, the Secretariat of which is held by SIS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2000, and conflicting national standards shall be withdrawn at the latest by November 2000.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This European Standard is divided into parts. The first part covers common criteria applicable to all heat transfer property measurements; each subsequent part covers the specific technical criteria applicable to each heat transfer property measurement method described in appropriate standards.

The following parts have been developed:

- Part 1: Common criteria;
- Part 2: Measurements by the guarded hot plate method;
- Part 3: Measurements by the heat flow meter method;
- Part 4: Measurements by hot box methods;
- Part 5: Measurements by pipe test methods.

Annex A of this European Standard is normative, the Annexes B and C are informative.

## 1 Scope

Part 5 of this standard provides specific technical criteria for the assessment of laboratories to undertake steady-state heat transfer property measurements on circular pipe insulation according to EN ISO 8497:1994.

It complements the common criteria in Part 1. Guidance is given on the organization and contents of the equipment manual, the calibration and maintenance files and the measurement procedure document.

It provides information on mandatory equipment performance specifications, on equipment description and on calculations for the equipment design and error analysis based on both EN ISO 8497:1994 on circular pipe apparatus and on Part 2 of this standard on the assessment of guarded hot plate apparatus.

It gives information on experimental procedures suitable for the assessment of equipment accuracy, based on both EN ISO 8497:1994 on circular pipe apparatus and on Part 2 of this standard on the assessment of guarded hot plate apparatus.

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

- |                          |                                                                                                                                                                                                                |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EN 1946-1:1999,          | <i>Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties - Part 1: Common criteria</i>                             |
| EN 1946-2:1999,          | <i>Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties - Part 2: Measurements by guarded hot plate method</i>    |
| EN 12667 <sup>1)</sup> , | <i>Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Products of high and medium thermal resistance</i> |
| EN ISO 7345,             | <i>Thermal insulation - Physical quantities and definitions (ISO 7345:1987)</i>                                                                                                                                |
| EN ISO 8497:1994,        | <i>Thermal insulation - Determination of steady-state thermal transmission properties of thermal insulation for circular pipes (ISO 8497:1994)</i>                                                             |
| prEN 13467:1999,         | <i>Thermal insulating products for building equipment and industrial installations - Determination of dimensions, squareness and linearity of preformed pipe insulation</i>                                    |

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<sup>1)</sup> To be published

### 3 Definitions

For the purposes of this part of the standard, the terms and definitions given in Part 1 of this standard, EN ISO 7345 and EN ISO 8497:1994 apply.

## 4 Equipment manual

### 4.1 General

The equipment manual shall provide the information specified in 5.2.2 to 5.2.5 of Part 1 of this standard and the information specified in this clause.

NOTE: Information common to more than one piece of equipment need not be duplicated, e.g. the principle, details of the design and operation of two pieces of equipment built to a common design.

Annex A gives all limiting values indicated in EN ISO 8497:1994 for equipment performance and testing conditions. This annex shall be used as a check list during the assessment process by the parties concerned to ensure compliance with all EN ISO 8497:1994 requirements.

### 4.2 Equipment performance specifications

The upper and lower limits of the relevant tested properties and testing conditions, including possible interactions between them, shall be specified:

- minimum and maximum external diameter of the specimen;
- minimum and maximum specimen thermal resistance;
- minimum and maximum temperature difference across the specimen;
- minimum cold side temperature;
- maximum hot side temperature;
- surrounding environment (temperature, relative humidity) at the ends of the specimen during the test, if required.

### 4.3 Equipment description

The following information shall be documented and shall be available for examination during the assessment:

- principle of operation (see clause 1 of EN ISO 8497:1994);
- type of apparatus: guarded-end apparatus, see 7.3 of EN ISO 8497:1994, or calibrated/calculated-end apparatus, see 7.4 of EN ISO 8497:1994;
- principal dimensions of apparatus, in particular length of test pipe centre, test pipe guard, test pipe diameter and gap width;
- simple diagrams illustrating the design of the equipment with special attention to the gap design (see clause 7.3 of EN ISO 8497:1994), cap design (if applicable, see 7.4 of EN ISO 8497:1994), jacket or added insulation (if applicable see 7.11 of EN ISO 8497:1994);
- position, connections and numbering of temperature sensors (see 7.6 of EN ISO 8497:1994);
- ambient control and main ancillary equipment (see 7.8 to 7.10 of EN ISO 8497:1994);
- details of data acquisition system and related computer programs for data analysis.

To avoid duplication, reference may be made to manuals supplied by the instrument manufacturers or to relevant clauses of EN ISO 8497:1994.

## 4.4 Equipment design and error analysis

### 4.4.1 General

With reference to the performance specification given in 4.2, details shall be given in the equipment manual on the design guidelines followed, and the error analysis.

Some guidelines on error analysis are given in this subclause; more specific information on some errors is supplied in Annex B, while error calculations are supplied in Annex C for some typical cases. For equipment having characteristics exactly as indicated in this subclause, or design details as indicated in Annex C, no further calculations are needed. In other circumstances similar calculations can be performed by analogy.

### 4.4.2 Axial heat flow rate and maximum specimen thickness

#### 4.4.2.1 General

The axial heat flow rate from the test section to the guard sections of the specimen affects the maximum specimen thickness. The axial heat flow rate shall not exceed that permitted by 9.5.2.2 of EN ISO 8497:1994 (1 % of heat flow rate of the test section, i.e. the end heat loss error shall be less than 1 %).

#### 4.4.2.2 Guarded-end apparatus

Table 1 shows for some apparatus having an overall pipe length of 1000 mm and other dimensions as given in the table, the maximum allowed specimen thickness according to the equations proposed in Annex B. Those expressions are based on 2.2.1 of ISO 8302:1991, see [1] in the Bibliography, when there is no end insulation and when the end temperature ratio,  $e$ , is 0;  $e$  is defined as  $(T_e - T_2)/(T_1 - T_2)$ , where  $T_1$  and  $T_2$  are respectively the temperatures of the hot and cold surfaces of the specimen, and  $T_e$  is the temperature at the ends of the specimen, assumed to be uniform.

NOTE: The end heat loss error is zero for homogeneous isotropic specimens when  $e$  is close to 0,5; the absolute value of the edge heat loss error increases almost symmetrically when  $e$  deviates on either side from 0,5. In the range  $0 \leq e \leq 1$ , this error is maximum for  $e = 0$ .

EXAMPLE: A temperature of the specimen ends of 50 °C, a temperature of the specimen cold side of 50 °C (so that the temperature difference between the ends and the cold side of the specimen is 0 °C) and a temperature of the specimen hot side of 150 °C (so that the temperature difference between the hot and cold side of the specimen is 100 °C) corresponds to  $e = 0$ . If the temperature of the specimen ends were of 60 °C, then it would be  $e = 0,1$ .

The data of the table can be applied to apparatus and specimens having all the dimensions multiplied by the same factor. Interpolation is allowed.

EXAMPLE: By considering a multiplying factor of 2,4, an apparatus has an overall pipe length of  $1\,000 \times 2,4 = 2\,400$  mm, the pipe centre length of  $800 \times 2,4 = 1\,920$  mm and a pipe diameter of  $100 \times 2,4 = 240$  mm. The resulting maximum specimen thickness, see the third line of Table 1, is  $70 \times 2,4 = 170$  mm (rounded to two significant figures).

**Table 1 - Maximum allowed specimen thickness for guarded end apparatus**

Dimensions in millimetres

| Overall pipe length | Pipe centre length | Pipe guard width | Pipe diameter | Maximum specimen thickness |
|---------------------|--------------------|------------------|---------------|----------------------------|
| 1 000               | 400                | 300              | 100           | 125                        |
| 1 000               | 700                | 150              | 100           | 90                         |
| 1 000               | 800                | 100              | 100           | 70                         |
| 1 000               | 400                | 300              | 50            | 110                        |
| 1 000               | 700                | 150              | 50            | 75                         |
| 1 000               | 800                | 100              | 50            | 60                         |
| 1 000               | 400                | 300              | 25            | 90                         |
| 1 000               | 700                | 150              | 25            | 65                         |
| 1 000               | 800                | 100              | 25            | 50                         |
| 1 000               | 400                | 300              | 12,5          | 80                         |
| 1 000               | 700                | 150              | 12,5          | 55                         |
| 1 000               | 800                | 100              | 12,5          | 45                         |
| 1 000               | 400                | 300              | 6             | 65                         |
| 1 000               | 700                | 150              | 6             | 45                         |
| 1 000               | 800                | 100              | 6             | 35                         |

Larger specimen thicknesses can be used for some specimens if insulation or temperature control is used at the ends of the specimen, or if auxiliary guards are installed.

When the maximum specimen thickness to be specified according to 4.2 exceeds the appropriate value given in Table 1, the axial heat flow rate shall be calculated. If, according to these calculations, the axial heat flow rate exceeds the values permitted by EN ISO 8497:1994, the performance check data shall be examined and, if no experimental evidence exists to substantiate the claimed maximum specimen thickness, the maximum specimen thickness to be specified according to 4.2 shall be reduced.

#### 4.4.2.3 Calibrated or calculated-end type apparatus

When corrections are applied for axial heat flow rate either through the calibration procedure indicated in 10.1 of EN ISO 8497:1994 or through the calculations indicated in 10.2 of EN ISO 8497:1994, the correction should not be larger than 3 % of the heat flow rate supplied to the specimen by the test pipe centre.

NOTE: This limit implies that the accuracy of the correction is 33 % or better. This figure is intended to make allowance for a similar difference between the thermal conductivity of the end cap and that of the specimen. Larger corrections are acceptable, provided that the uncertainty in the corrected heat flow rate supplied to the specimen by the test pipe centre is within the 1 % required by 9.5.2.2 of EN ISO 8497:1994.

#### 4.4.3 Maximum gap width and minimum specimen thickness

The gap width,  $g$ , in guarded-end apparatus should be less than 1 % of the length of the test pipe centre.

NOTE: Considering that the test section length,  $L$ , is defined (in 9.1.1 of EN ISO 8497:1994) as the distance from gap centre to gap centre, the above requirement keeps within 1 % the uncertainty in the definition of the area through which the heat flow at the rate  $\Phi$  passes, supplied to the specimen by the test pipe centre, even when the specimen thickness is comparable or less than the gap width. In this situation the area through which the heat flow rate supplied by the test pipe centre passes approaches that of the test pipe centre itself from gap edge to gap edge. When, on the other hand, the specimen thickness is far larger than the gap width (e.g. 10 times) the border of this area is defined by the lines passing through the centre of the gaps, i.e. the uncertainty on the test section,  $L$ , is in any case less than the gap width,  $g$ .

The minimum specimen thickness shall also be checked against the expected air gap between the specimen and the apparatus, see 4.4.9.

#### 4.4.4 Imbalance error

The imbalance heat flow rate,  $\Phi_g$ , through both the specimen and the apparatus (both gaps) shall be less than 1 % of the heat flow rate,  $\Phi$ , supplied to the specimen by the test pipe centre (according to 9.4 of EN ISO 8497:1994).

The imbalance heat flow rate  $\Phi_g$  can be expressed as follows (according to 4.4.4 of Part 2 of this standard):

$$\Phi_g = (\Phi_o + \lambda c) \Delta T_g \quad (1)$$

where  $\Phi_o$ , representing the heat flow rate for a 1 K gap imbalance through the apparatus itself, is the sum of:

- $\Phi_a$  through the air in the gap;
- $\Phi_r$  by radiation through the gap;
- $\Phi_m$  through the mechanical connections through the gap;
- $\Phi_c$  through copper wires;
- $\Phi_w$  through metal wires (excluding copper)

and  $\lambda c$  is the heat flow rate through the specimen (both gaps) due to a 1 K gap imbalance with  $c$  expressed by the following equation:

$$c = (2 d_o) \ln (4/(1 - \exp(-\pi g/d))) \quad (2)$$

In equation (2)  $d_o$  is the outer diameter of the test pipe,  $g$  is the gap width and  $d$  is the maximum expected specimen thickness.

$\Delta T_g$  shall be such that  $\Phi_g$  in equation (1) is less than 1 % of the heat flow rate  $\Phi$ .

NOTE: To calculate the components of  $\Phi_o$ , the elementary equations of heat transfer through a plane layer can be used.